

**CLAIMS**

1. Thermal insulation structure comprising at least one flexible layer based on compressed expanded graphite particles characterised in that the  
5 density of the said flexible layer, called dense compressed expanded graphite layer, is equal to at least  $0.4 \text{ g/cm}^3$  ( $400 \text{ kg/m}^3$ ) and in that the said thermal insulation structure also comprises another layer called sub-dense compressed expanded graphite layer, based on compressed graphite particles with a lower density, typically less than  $0.4 \text{ g/cm}^3$   
10 ( $400 \text{ kg/m}^3$ ).
2. Thermal insulation structure according to claim 1 in which the said dense compressed expanded graphite layer has a density of between  $0.5$  and  $1.6 \text{ g/cm}^3$  ( $500$  and  $1600 \text{ kg/m}^3$ ) and the said sub-dense compressed  
15 expanded graphite layer has a density of between  $0.05$  and  $0.3 \text{ g/cm}^3$  ( $50$  and  $300 \text{ kg/m}^3$ ).
3. Thermal insulation structure according to claim 1 or 2 in which the said dense and sub-dense layers made of compressed expanded graphite  
20 are adjacent and are bonded to each other by carbonation of a carbonisable binding agent, typically phenolic resin, furfuryl resin or pitch.
4. Thermal insulation structure according to claim 3 in which the adjacent dense and sub-dense layers made of compressed expanded graphite  
25 are intimately bonded together over their entire contact surface.
5. Thermal insulation structure according to any one of claims 1 to 4 obtained by stacking the said adjacent dense and sub-dense layers, with  
30 one alternation of dense and sub-dense layers made of compressed expanded graphite.

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- 5 6. Thermal insulation structure according to any one of claims 1 to 5 in which the said sub-dense layer or layers made of compressed expanded graphite have a total thickness of less than 40 mm, and typically between 5 and 20 mm.
- 10 7. Thermal insulation structure according to any one of claims 1 to 6 in which the said dense layer or layers made of compressed expanded graphite have a total thickness of less than 2 mm, and typically of between 0.5 and 1.5 mm.
- 15 8. Thermal insulation element designed to be fitted on furnaces operating in a non-oxidising atmosphere and at temperatures of more than 800°C, characterised in that it comprises a thermal insulation structure according to any one of claims 1 to 7.
- 20 9. Thermal insulation element according to claim 8, characterised in that it forms part of the wall of the chamber of a furnace operating at temperatures of more than 800°C and in a non-oxidising atmosphere.
- 25 10. Thermal insulation element according to claim 9, characterised in that it is in the form of a brick, such that the assembly of several of these bricks forms the surface of the combustion chamber of the said furnace.
- 30 11. Thermal insulation element according to claim 9, characterised in that it is in the form of a cylindrical wall in one or more parts making up the combustion chamber of the said furnace.
12. Thermal insulation element according to any one of claims 8 to 11, characterised in that its apparent surface is covered with a dense compressed expanded graphite layer with a density of more than

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0.4 g/cm<sup>3</sup> (400 kg/m<sup>3</sup>) typically between 0.5 and 1.6 g/cm<sup>3</sup> (500 and 1600 kg/m<sup>3</sup>).

13. Method for manufacturing a thermal insulation structure, characterised  
5 in that it comprises the following steps:
- a) making at least one "thick" sub-dense strip with a thickness of less than 40 mm, typically between 5 and 20 mm, by limiting the density obtained by compression of graphite particles to small values of the order of 0.1 g/cm<sup>3</sup> (100 kg/m<sup>3</sup>) and typically within the range of 0.05 g/cm<sup>3</sup>  
10 (50 kg/m<sup>3</sup>) to 0.30 g/cm<sup>3</sup> (300 kg/m<sup>3</sup>);
- b) making a "thin" dense strip with a thickness of less than 2 mm, typically between 0.15 and 1.5 mm, with a density within the range of 0.5 to 1.6 g/cm<sup>3</sup> (500 to 1600 kg/m<sup>3</sup>);
- c) joining said two strips, typically by co-lamination, so as to form multilayer  
15 structures that comprise an alternation of thick sub-dense / thin dense layers, with at least two elements, said assembling being made as follows:
- c1) the said sub-dense thick strip is coated with a liquid solution rich in carbon, typically a phenolic resin, a furfuryl resin or pitch;
- c2) almost all solvents in the solution, if any, are then eliminated by  
20 slow drying;
- c3) the said dense thin strip is then added to the coated surface;
- c4) heat treatment of thus joined strips under a non-oxidising atmosphere at a temperature of not less than 800°C.
- 25 14. Manufacturing method according to claim 13, modified so that two dense thin strips are made in step b) and in that a sub-dense thick strip is placed, typically by co-lamination, between the said two thin strips in step c).

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15. Manufacturing method according to claim 13, modified so that two sub-dense thick strips are made in step b) and in that a dense thin strip is placed, typically with co-lamination, between the said two sub-dense thick strips in step c).

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16. Method for manufacturing a brick of a thermal insulation element, characterised in that a thermal insulation structure is made according to the method in claim 14, and in that the structures thus made are then cut to the required dimensions.

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17. Method for manufacturing a thermal insulation element, characterised in that it comprises the following steps:

a) a thermal insulation structure is made according to the method in claim 13, the said structure being sufficiently flexible so that it can be wound spirally on a cylindrical support afterwards;

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b) before winding, the sub-dense thick layer of the structure is coated with a liquid solution rich in carbon, typically a phenolic resin, a furfuryl resin or pitch, and then almost all solvents in the solution, if any, are eliminated by slow drying;

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c) the structure thus obtained is wound spirally on several layers so as to obtain a cylindrical jacket with the required thickness;

d) the cylindrical face of the said cylindrical jacket that is occupied by the sub-dense layer is covered with a flexible strip made of dense compressed expanded graphite;

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e) the jacket is heat treated under a non-oxidising atmosphere at a temperature equal to at least the temperatures that the thermal insulation will need to resist during use, typically 800°C, and preferably 1000°C or more.

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18. Method for manufacturing a thermal insulation element designed to be fitted on furnaces operating in a non-oxidising atmosphere and at temperatures of more than 800°C, characterised in that it comprises the following steps:

- 5 a) a sub-dense compressed expanded graphite layer is made with a density of less than 0.4 g/cm<sup>3</sup> and with a thickness of less than 25 mm,
- b) the said strip is curved so that it is in the form of a portion of a cylinder,
- c) after bending, the strip is glued,
- d) a reinforcing layer is applied made of a dense compressed expanded  
10 graphite, with a density of more than 0.4 g/cm<sup>3</sup>, on one or two of the faces of the curved strip,
- e) the assembly is then heat treated while being held in shape by a graphite conforming jig surrounding the product.